

# A low noise CsI detector array for the measurement of parity non-conservation in

$$\vec{n} + p \rightarrow D + \gamma$$

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# Who is NPDGamma ?

Currently under construction at the LANSCE

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# Motivation

Measurement of the weak pion-nucleon coupling  $H_\pi^1$

At low energies (  $< 300$  MeV) the weak interaction between nucleons can be described in terms of meson and hadron degrees of freedom.

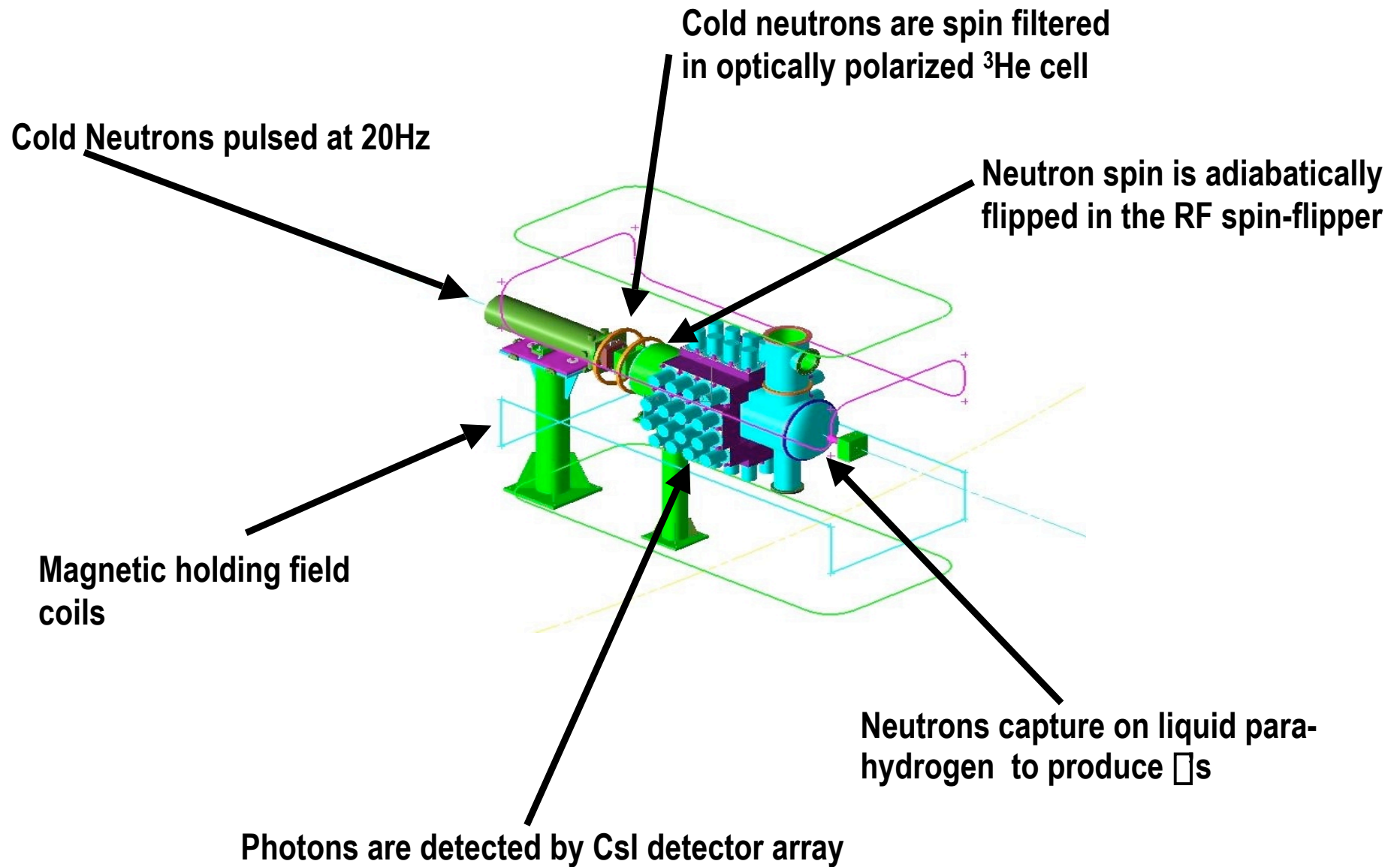
The radiative capture of cold polarized neutrons on protons is the simplest process in which to study the hadronic weak interaction. (Two body)

$A_\pi$  is the parity violating asymmetry in the distribution of  $\pi$ s emitted in the radiative n-p capture.

The DDH predicted size of the asymmetry is

$$A_\pi \approx 0.045 H_\pi^1$$
$$A_\pi \approx 5 \times 10^{-8}$$

# Experimental setup

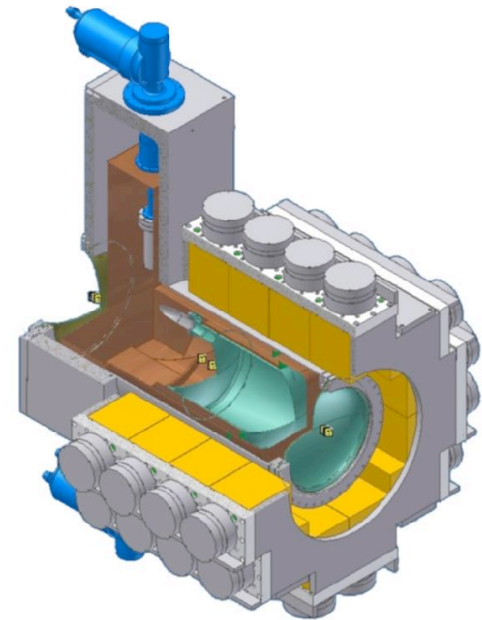


# Detector Array

The 3 $\sigma$  detector array employs 48 CsI(Tl) scintillator crystals, each coupled with a 3 inch vacuum photo-diode.

Gain provided by low noise solid-state preamplifiers.  
Gains are magnetic field insensitive.

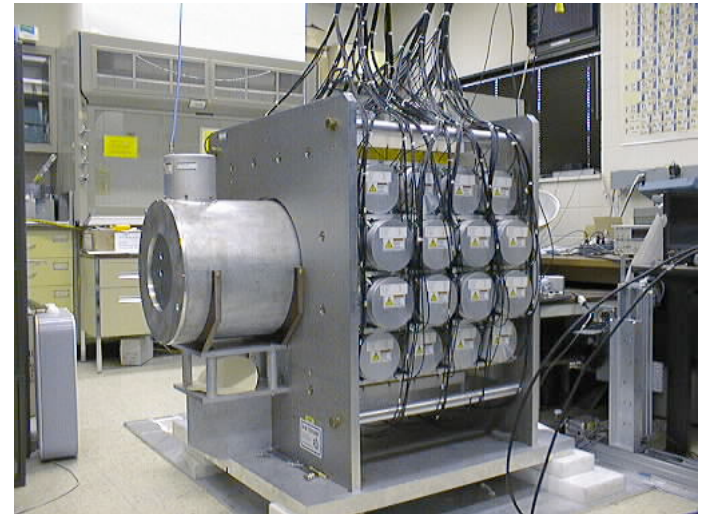
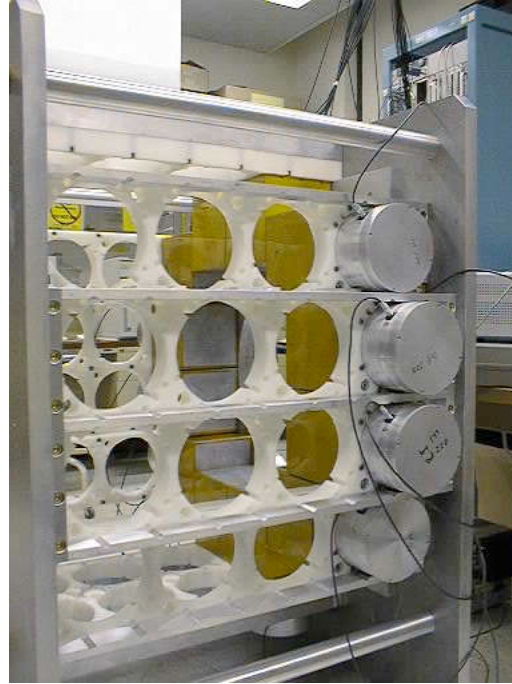
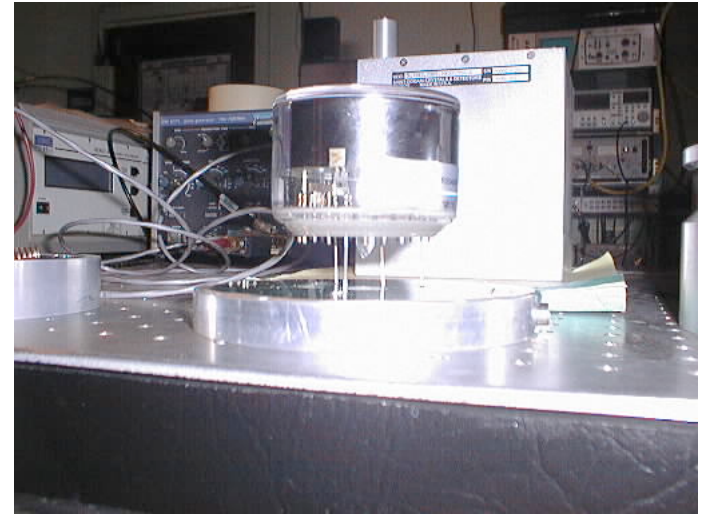
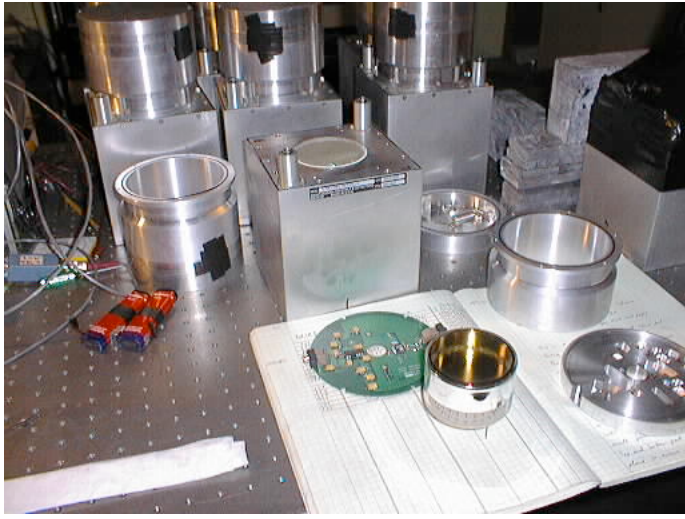
Expect  $5 \times 10^7$   $\sigma$ 's/pulse into the detector array.



## Important criteria:

1. Current mode  
Large number of events  $\rightarrow$  Pulse counting impossible  
 $\rightarrow$  Counting statistics from shot noise at photo-cathode
2. Low noise  
Measurement accuracy  $\rightarrow$  Dominated by counting statistics
3. No additive false asymmetry  
Spin flipper systematic effect  $\rightarrow$  Present with or without beam. Addition to signal from spin correlated electronic pickup
4. No multiplicative false asymmetry  
Spin flipper systematic effect  $\rightarrow$  Spin correlated gain change in the photodiode



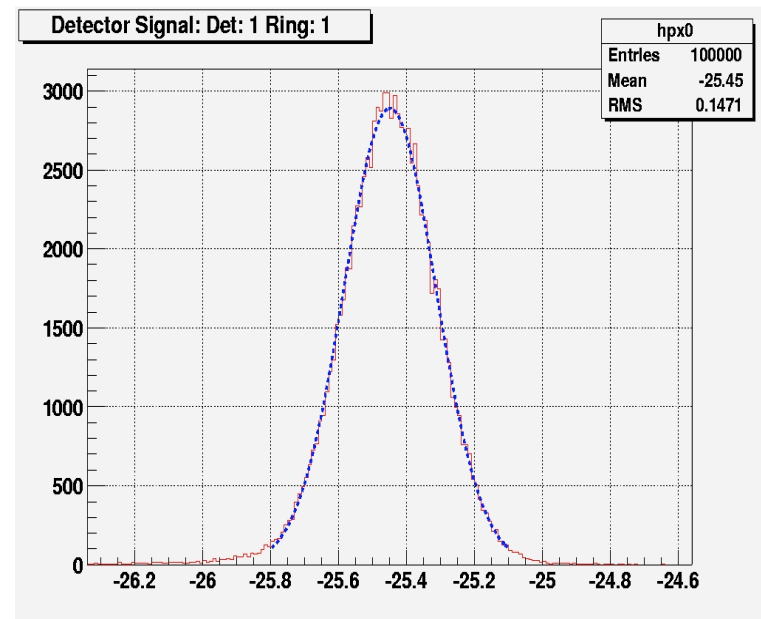
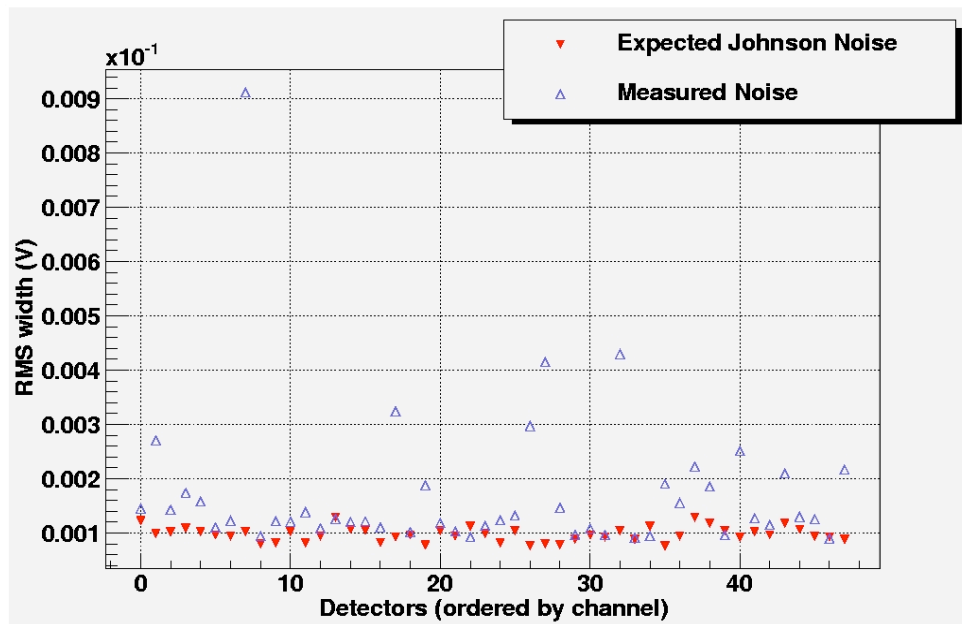


# Detector Noise Tests

The detector pre-amplifier was designed to operate close to the level expected from thermal fluctuations.

The predicted total noise in the preamplifier is

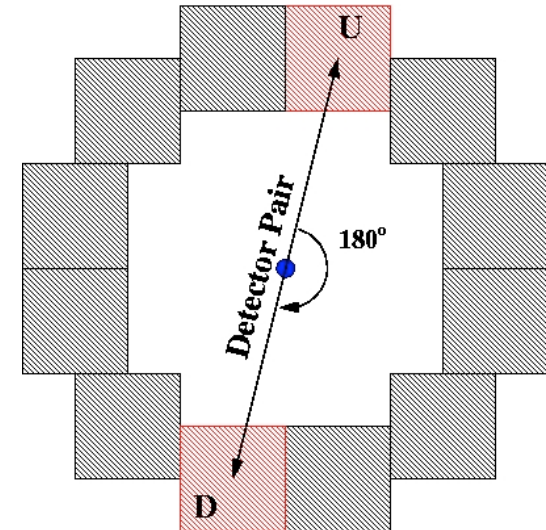
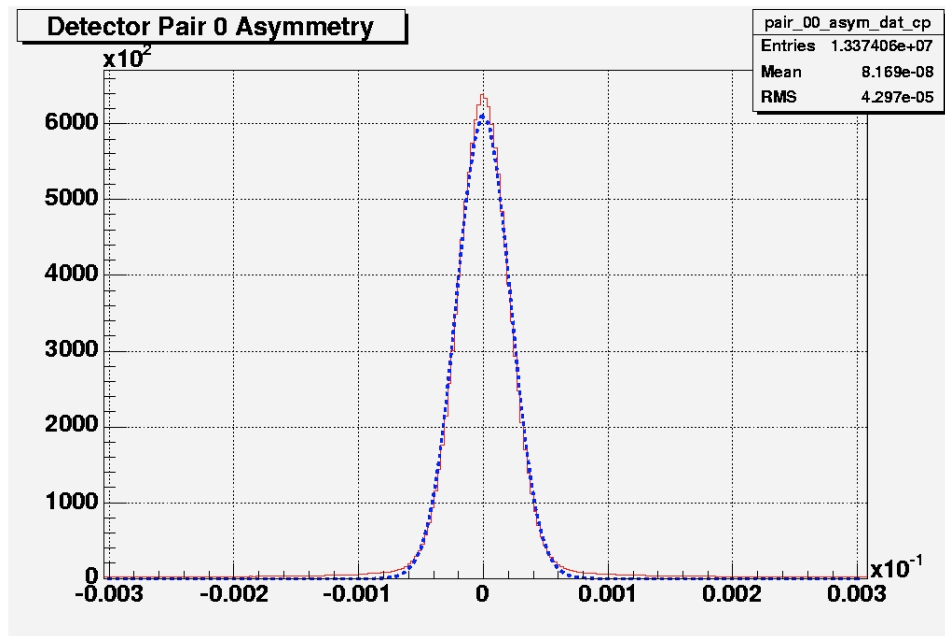
$$S\left(\sqrt{i_{\text{johanson}}^2 + i_{\text{amp}}^2}\right) \approx 21 \text{ fA} / \sqrt{\text{Hz}} \quad \square \quad \square 0.1 \text{ mV} \quad \text{RMS}$$



# Additive Asymmetry due to Electronic Noise

The time needed to measure the asymmetry to the  $5 \times 10^{-9}$  level due to electronic noise is  $\sim 3$  hours of run time.

Predicted time (from predicted noise) is approximately 1 hour



$$A_{\square}(t) = \frac{U_{\uparrow} \square D_{\uparrow} \square (U_{\square} \square D_{\square})}{U_{\uparrow} + D_{\uparrow} + U_{\square} + D_{\square}}$$

( $\uparrow, \square$  = Neutron Spin)

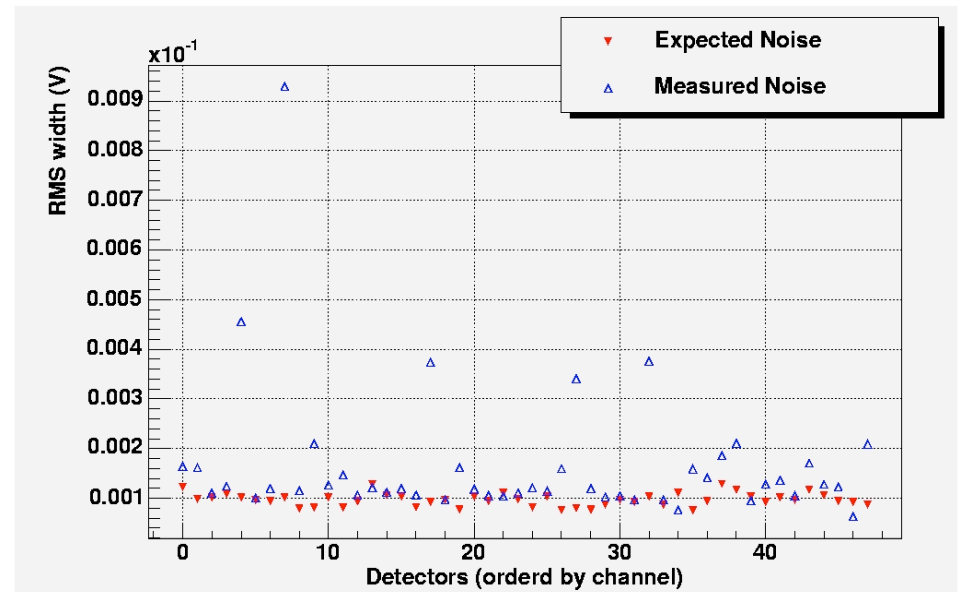
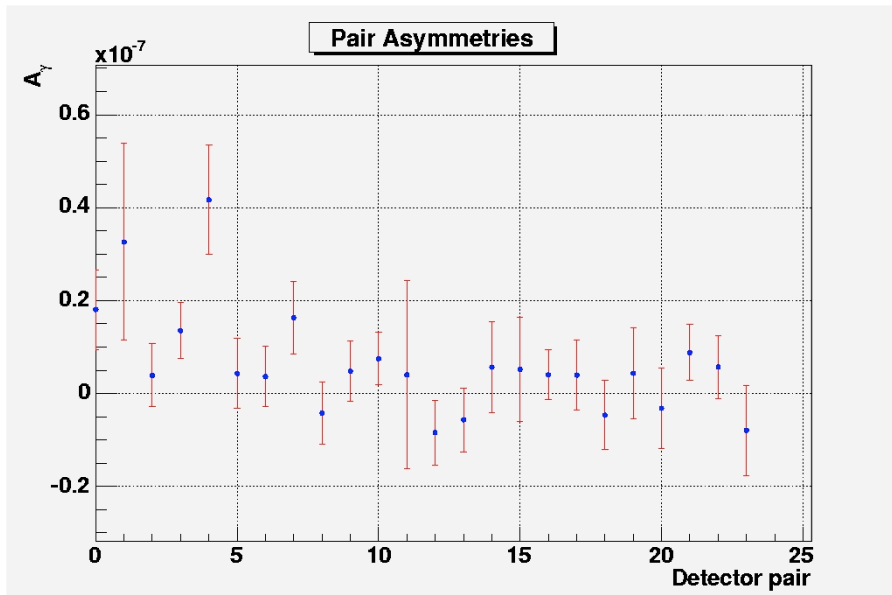


# Additive Asymmetry with Spin Flipper

The time needed to measure the asymmetry with the spin flipper to

$$A_{\square} = (\pm 1 \pm 3) \times 10^{-9}$$

Is ~ 5 hours of run time.



# Multiplicative Asymmetry with Spin Flipper and LEDs

We need a signal into the vacuum-photodiode to see a multiplicative effect.

For beam-on or LED on, the measurement time is dominated by counting statistics from shot noise.

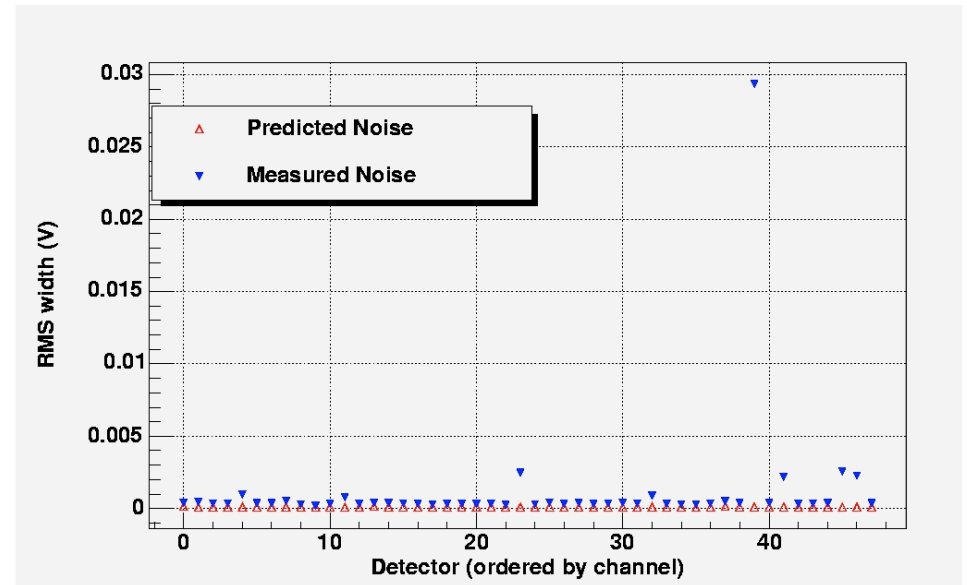
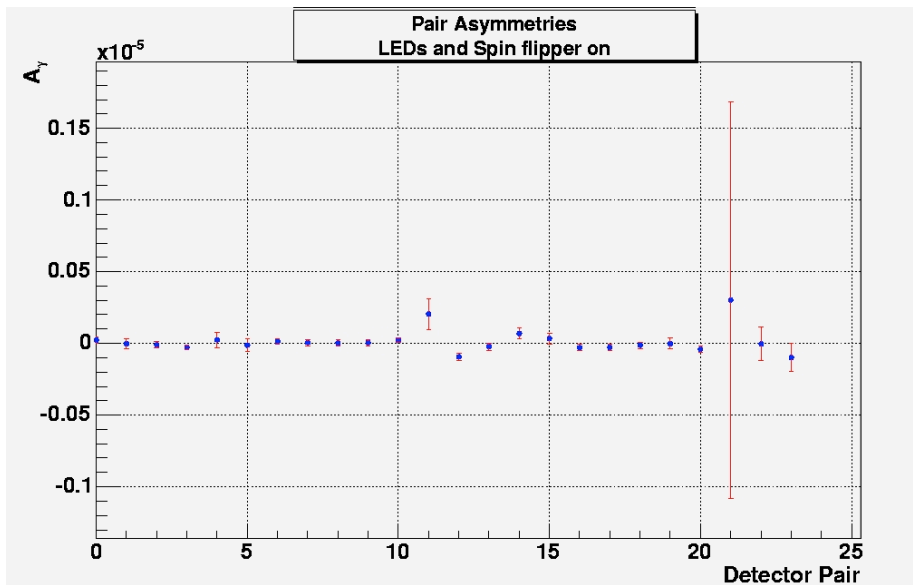
$$S(i_s) = \sqrt{2eI} \approx 98 \text{ fA} / \sqrt{\text{Hz}} \approx \approx 5 \text{ hours}$$

$$I \approx 28 \text{ nA}$$

The actual time needed to measure the asymmetry with the spin flipper and LEDs to

$$A_{\square} = (8 \pm 5) \times 10^{-9}$$

Is  $\sim 11$  hours of run time.



The time actually needed to measure to the desired accuracy is longer  
because of the noise generated by the LEDs

# Conclusions

- **Detectors operate as designed**
- **Noise levels low enough to allow operation at counting statistics**
- **But noise levels can be lowered further to correspond to predicted levels**
- **No observed systematic effect (additive or multiplicative)**
- **Experiment will be commissioned starting January 2004**
- **First (1000 hours of run time) results expected in the Fall of 2004**